

Rainwater as an Alternative to Mains Water

Preventing Contamination & Effecting Purification

ATA Melbourne Branch Meeting

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Agenda

- Effect of climate change on Melbourne's water supplies
- Victorian Government Rainwater Tank Rebates
- Comparative safety of mains water and stored rainwater
- Where to use stored rainwater
- Preventing contamination of stored rainwater
- Simple purification techniques - passive and active
- Factors to consider when choosing a tank
- Producing ultra-pure water for drinking and cooking

Purpose

Thesis

- Raindrops in Melbourne are pure enough
 - They are a bit acidic
 - The first flush may bring down a bit of pollution
- A raindrops can easily become unsafe between the time it falls on to the roof till when it comes out of the tap.

Purpose

- To trace the movement of a raindrop through to the tap
- To identify simple measures that we can take to:
 - Prevent contamination
 - Effect purification

Objective:

- To show how to **safely** use stored rainwater as an alternative to mains water for **every** household purpose

Climate Change and Melbourne's water supplies

More infrequent but bigger rain events but overall less rainfall

Less runoff due to wildfires, logging and "green drought"

Low water levels in dams

Higher evaporation rates from catchments and dams

Schemes to capture and purify urban storm water

Schemes to recycle sewage

Desalination plant - \$\$\$ and black balloons

Piping in (i.e. pinching) water from Northern Victoria

Shipping in water from New Zealand?

End Result = rationing of mains water through steep price rises and water restrictions

Increasing population make things worse

Victorian Government Rainwater Tank Rebates

Rebate Amounts:

- **\$500**: for 2,000 – 4,999 litres, connected to toilet and/or laundry
- **\$900**: for 5,000+ litres, connected to toilet **or** laundry
- **\$1,000**: for 5,000+ litres capacity, connected to toilet **and** laundry

This government measure is:

- Safe, i.e. negligible risk to health
- Positive measure to reduce water consumption

If used as a replacement for mains water in Melbourne:

- A 1,000 litre tank estimated to save 56,000 litres per year
- A 10,000 litre tank estimated to save 87,000 litres per year

Are these calculations based on averages or actuals?

Do they consider fewer but bigger rainfall events dues to climate change?

Do they consider first flush diversion, especially on “mizzly” days?

- Affordable/feasible for many people. Payback period?
- Provides a level of water security against mains failure

Why are the authorities being so cautious?

Why are they encouraging us to use stored rainwater for:

- Garden
- Toilet
- Laundry

And possibly for:

- Hot Water Service

But not for:

- Shower
- Vanity
- Dishwashing – Kitchen Sink and Dishwasher
- Cooking & Drinking

To avoid risks to health

How safe is mains water?

Melbourne's tap water is regarded as one of the best on the world

Sydney's 1998 Giardia and Cryptosporidium scare

Contamination of Canberra's water after bushfires. How scared is the government of a wildfire in the Thomson catchment?

“Drinking water failing the test”, Herald Sun, 12th March 2008

- E. coli found in 1% of tests. Indicates poo, probably animal origin
- Presence of aluminium and lead. Suggests dead zone stirred up
- Presence of blue-green algae. Indicates high nutrient content, heat and sun
- Complaints about foul-tasting water. Suggests stagnation and low oxygen

This is despite best practices for treating water and continual testing

Conclusion: On-going drought appears to be making harder to keep water safe

How is mains water treated?

Full treatment includes:

- Coagulation and clarification to cause the colour and turbidity particles to settle out
- Filtration to remove most of the remaining suspended solids
- Disinfection, i.e. chlorination. Chlorination produces toxic chemicals - trihalomethanes - when microbes die. It is best to filter these out using activated charcoal before drinking
- pH correction. To neutral pH (7.0). Reservoir water and rainwater are both acidic. Acid water can corrode copper pipes. Rainwater is also slightly acidic (pH 5.5)
- Fluoridation
- Sludge processing
- Test, test and test again to ensure it is safe

How safe is stored rainwater?

What are the risks to health from drinking stored rainwater?

- None, unless it has been contaminated
- Lack of fluoride – risk or benefit? Different issue

Conclusion from a scientific study:

- Gastroenteritis ... is significant ... among young children
- About 50% of young children in Adelaide, who were regular consumers of tank rainwater, were at no greater odds of gastroenteritis than those who drank treated public mains water
- In fact, gastro was lower in children who drank tank water
- Tank water is safe despite many collection systems being old and not conforming to current best practice, eg. no first-flush diverters

Also, generations of country folk have consumed tank water

Conclusion: Tank water is safe to drink if we take all reasonable steps to prevent its contamination

Stored rainwater is scarce - use it wisely

Stored rainwater cannot satisfy all the needs of a household. In most households it will supplement mains water, not replace it. Therefore, we must use it wisely

Despite the recommendation of Health Authorities to only use stored rainwater on garden, toilet and laundry, consider using it for all household purposes **except** the garden

If “Class A purple tap” water is available, i.e. water that can be safely stored, eg. treated storm water, then use it, rather than rainwater, in the toilet or laundry

Consider using recycled water that is not to Class A standard in subterranean irrigation or in dispersion trench to keep the garden green and to stop the foundations from cracking

Stay safe - always think safety first

Are you prepared to risk your family's health?



Preventing contamination - On Roof & Gutters

Avoid overhanging trees

Prevent possums, rodents from getting on to roof (good luck!)

Keep roof tiles free of moss, algae, flaking paint and loose material

Use safe paint on roof

Avoid lead flashing or treated timber that may leach poisons

Use gutter guards where leaves are a problem

- Screened mesh. Avoid curved barriers that will collect leaves on upper side
- Double layer - top layer excludes leaves, bottom layer collects water

If gutters are not screened use leaf diverters. Leaf diverters prevent leaves and other large particles from entering downpipe

Carry out regular maintenance

Preventing Contamination - In Downpipes

First flush diverter - diverts, first 20 or so litres at each downpipe to prevent dust, heavy metals, pollens, bird droppings etc. from entering tank

Downpipe Systems - wet and dry

- Wet systems constantly hold water in underground pipes - water becomes stagnant and potential breeding ground for mosquitoes. Must have mosquito prevention flaps at top of downpipe
- Dry downpipe system allows water to drain directly into the tank. This system is preferred because it avoids stagnant water



Preventing Contamination - In Tank

“Calmed Inlet” ensures that rainwater enters the tank in a way that it doesn’t stir up dead zone. Oxygen-rich water enters at the bottom of the tank at a low velocity and in an upwards direction

Overflow siphon. Skims off pollen and other floaties in the film on the water surface when tank is overflowing

Prevent mosquitoes, insects and rodents getting into tank from both the inlet and the overflow

Prevent backflow at overflow - only applicable to underground tanks

Prevent entry of sunlight. Limits algal growth

Keep tank shaded and cool. Limits growth of algae and bacteria. Underground tank is ideal.

Simple Passive Purification Techniques

Allow Settling. Let the water settle for a few days after a rain event - use mains water instead. Suspended particles will settle by themselves

Increase storage time

- A “long tank” with inlet at one end and water removal from the other will increase settling time
- A “virtual tank” is ideal

Provide an Air Zone. A large surface area will allow oxygen to dissolve into water, and keep it fresh-tasting

Let the Dead Zone be. Effectively attracts and binds mud, chemicals and microbial contaminants. Leave this layer be for at least 5 years. Same logic as Bay dredging

Take water from 150 mm below surface. Best water is here. Use Floating pump intake but stay clear of Dead Zone

Choosing a Tank - Other factors to consider

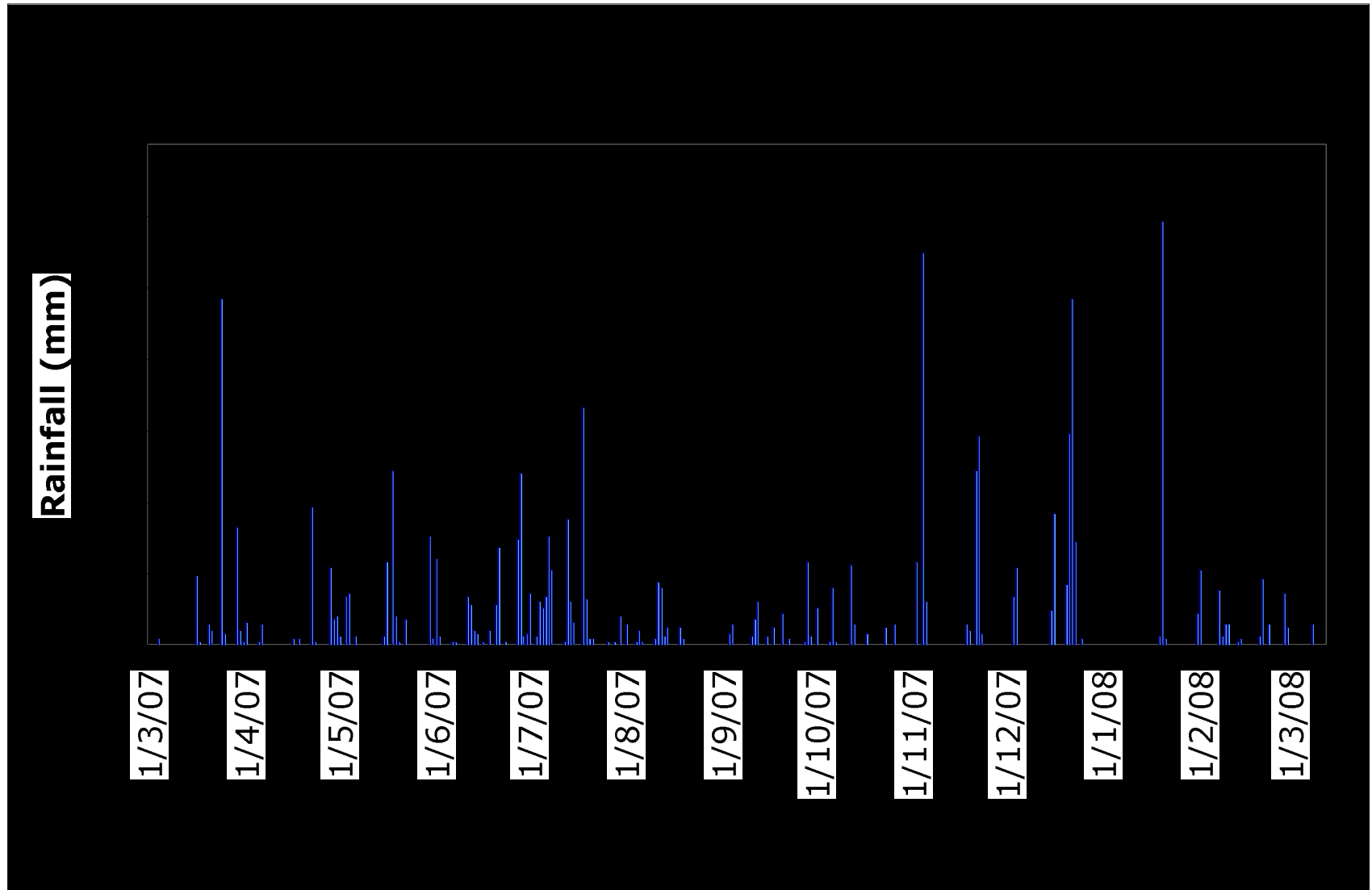
- Above-ground, below-floor, in-slab, underground...
- Type. Plastic, bladder, concrete, metal, scoria (see Bolton Reserve Storm water Retention project)...
- Funds - choose as big as you can afford. Aim to capture all water from large (eg. 50 mm) downpours. Aim to connect all down-pipes
- Size & Location. Tank can be taken to, and will fit into available space
- Local government regulations re tank siting
- Shading. Above-ground tank should be shaded
- Access to a) clean the tank's inlet strain, and b) the inside of the tank
- Create a single "virtual tank" by connecting many tanks. Connected tanks need to have same top level. Try to add water only to 'first' tank and remove water only from the 'last' tank

I prefer an underground tank



...because I don't want the tank to take up a lot of the garden

Try to size tanks for large downpours



How relevant are *rainfall averages* to sizing a tank? 18

Simple Active Purification - Slow Sand Filtration

Continuously pass water slowly downward through a container of sand

Sand should be sharp-edged to provide maximum surface area. Rockwool is also an ideal medium

Largest sand particles are at top, smallest at bottom

The water moves slowly by gravity only

Physical removal of tiny particles, including microbes

Sand is colonized by friendly microbes that kill the nasties

Aeration – adds oxygen and that keeps water “fresh tasting”

Low flow rate suits solar-powered pump

Is especially good for removing organic matter, fungi, bad bacteria and even some viruses

Plumbing to taps

Adhere to plumbing regulations, eg.

- Water authorities are very unhappy (i.e. livid) if water meter runs backwards. They fear that we will pollute the mains water
- Overflow must be connected to storm water drain

Maintain constant pressure at taps.

- Consider someone turning a tap while you are having a shower.
- Size of pressure pump and diameter of pipes affect pressure on

3-phase pumps are more efficient and much last longer

Submersible pumps are almost silent and won't irritate you or your neighbours. Above-ground pumps require an acoustic enclosure

Consider

- Having an easily visible gauge
- Automatically switching from tank water to mains water when the latter is low
- Manually switching to tank water to allow for a settling period after rain
- Keeping some water in reserve and requiring manual intervention to use it

Other Treatment Options Worth Considering

pH Correction

- Rainwater is slightly acidic (pH 5.5) and can corrode copper pipes and fittings
- Consider installing a calcite cartridge filter after the pump to correct the pH
- A concrete tank will also correct the pH. What else does it add to the water?

Ultraviolet Sterilisation

- UV light kills bacteria, fungi and protozoan cysts including Giardia and Cryptosporidium.
- The water needs to be very clear for the UV treatment to be effective
- Restrict to drinking water rather than whole-of-house?

Ozone

Aeration

- Oxygen breaks down organic compounds converting them to less harmful forms compared to what happens if there is low oxygen
- Add air near bottom of tank but don't disturb the Dead Zone
- Use fish tank technology?

Other Treatment Options

Chlorination

- Requires dedicated on-going maintenance effort
- Tricky to get dose right
- Produces trihalomethanes as bacteria and organic matter break down
- Victorian Government Department of Human Services reckons it's a good idea

Filtration

- Potential bacteria & fungus farm if using non-chlorinated water
- Useful for removing the toxic by-products of chlorination

Pasteurisation (or Boiling)

- Raising water (or milk) to a fixed temperature for a fixed time, eg. 68° for 30 minutes (batch), 72° for 20 seconds (continuous flow) or 138° for a fraction of a second (UHT Milk)
- 65°C for 5 minutes kills off 99.999% of Worms, Protozoa cysts (Giardia, Cryptosporidium, Entamoeba), Cholera, E. coli, Shigella, Salmonella typhi, Rotavirus and Hepatitis A virus
- There must be a continuous-flow solar alternative around the corner that ensures that each drop of water is raised to a given temperature for the required period. Surely a simple matter of engineering?
- Pasteurised water would need be stored separately from tank water

Ultra-pure water for drinking and cooking

We saw earlier that despite the best efforts of the Water Authorities and/or the Home Owner, both mains water and stored rainwater pose a risk to human consumption

At best, many people would say that tap water tastes “bad” compared to ultra-pure, well-aerated water. Try comparing for yourself

Even assuming that the mains/tank water are free of germs, they still may contain:

- Salts
- Heavy metals
- Poisons, eg. spray drift
- Toxins - bacterial and other
- Chlorine and trihalomethanes resulting from chlorination
- Fluoride ...

If you would prefer to consume ultra-pure water for drinking and cooking then you need to further purify both mains and tank water

Ideally the ultra-pure water would be stored in a header tank and would supply a single tap.

Chlorinated mains water and unchlorinated tank water would normally be treated differently. However, we want to find a single method to treat both

Ultra-purifying water using Reverse Osmosis

There are (at least) two simple ways of ultra-purifying water

- Reverse Osmosis. Affordable continuous flow systems are readily available
- Distillation. Affordable continuous flow system not available?

Under-sink Reverse Osmosis units are good for treating mains water

- RO uses water pressure to separate pure water from 'polluted' water
- Under-sink RO uses no electricity - unlike proposed desalination plant
- However, more than 80% of input water goes down the drain. Divert this 'effluent' to grey water or consider returning it to the tank
- Large particles reduce life of RO membrane - need to pre-filter
- Chlorine destroys the RO membrane - need to pre-filter

The under-sink RO unit cannot take unchlorinated tank water because the pre-filters will become fungus and bacteria farms. Avoid this problem by pre-treating tank water with one of following

- UV Sterilisation
- Pasteurisation / Boiling (if available)

Ultra-purifying mains water using Distillation

There basic idea of distillation is to boil water and to capture the condensate while preventing re-contamination

We know how to:

- Boil water using the sun
 - Use the sun to distill water, eg. Thamesford's Solar Water Purifier, and that these stills work best if the input water is boiling
 - Use iron-free glass to let through the sun's UV and kill off germs
 - Use charcoal filters to remove the sometimes smelly volatile organic compounds (VOC) that evaporate at lower temperatures than water, eg. alcohol evaporates at 70°
 - Return oxygen into distilled water to freshen up its taste
 - Store the ultra-filtered water safely to prevent its re-contamination
- ...yet no one has put it all together into an affordable, complete, supported, commercial off the shelf system

How hard can it be? Isn't it a simple matter of engineering?

Conclusions

- Climate change is making mains water scarcer, costlier and harder to keep safe
- By following simple sensible precautions, stored rainwater water is no more risky than mains water
- Health authorities are presumably not prepared to recommend the use of stored rainwater for all household purposes because some home owners will not take the simple measures required to prevent contamination and to effect purification
- Taking into account Vic Government rainwater tank rebates, many people will find it attractive to use stored rainwater as an alternative to mains water for **every** household purpose; and if done correctly, it is **safe** to do so
- Stored rainwater is scarce - use it wisely. Don't use it on garden, in toilet or in laundry if "purple tap" water is available
- Some people may want to ultra-purify both mains water and rainwater for the purposes of drinking and cooking

Sources

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